A REPLY TO MR. EDISON.

BY GEORGE WESTINGHOUSE, JR., PRESIDENT OF THE WESTINGHOUSE ELECTRIC COMPANY.

NO ONE will now question the great benefit of the electric light to the public. By the rays of the brilliant arc lamp our streets are better lighted than ever before, with a corresponding increase in security both to life and property, while the incandescent lamp supplies our homes with the most agreeable artificial illumination known to science, and one which, at the same time, is absolutely free from the deleterious products of combustion incident to the use of gas or oil.

The use of electricity for supplying light and power has now become as much a part of our every-day life as the railway, the steamship, the street-car, or the gas supply. In fact, we live in a time when power is made in every way subservient to the comfort of the people. It is employed in nearly every useful industry, with a full knowledge that such employment has been and always must be attended with an appreciable degree of danger. Electricity is one manifestation of power. It represents a form of mechanical energy capable of being utilized for innumerable purposes. Indeed, were it a question of prohibiting the use not merely of electricity, but of all other things dangerous to life, we would no longer have fires to warm us or light to enable us to see, and, in fact, would be deprived of most of the necessaries and comforts of existence. As has been the case with the utilization of all other forms of energy, the demand for the most economical methods will ultimately prevail, provided these can be made safe, as they most certainly can, by the exercise of proper precautions.

Electric lighting, unlike many other industries protected by patents, has been followed with keen interest at every step by the public at large, but among more immediately interested par-

ties the struggle for the control of the electric light and power business has never been exceeded in bitterness by any of the historical commercial controversies of a former day. Thousands of persons have large pecuniary interests at stake, and, as might be expected, many of them view this great subject solely from the stand-point of self-interest. That the public may to some extent understand the mass of literature now being printed with reference to the use of electric currents of both high and low tension, it is necessary that something of the story of this business rivalry should be told.

The successful use of the Jablochkoff electric light in Paris, in 1878, was the beginning of a new era in a field which had not remained wholly uncultivated during the preceding thirty years, although with unimportant commercial results. In 1877 and 1878 we find William E. Sawyer, Charles F. Brush, Hiram S. Maxim, Edward Weston, Thomas A. Edison, and others entering this alluring field of invention. In 1877 Sawyer took out three patents of more than ordinary importance in view of what has since become the practice in electric lighting. Early in 1878 he associated with himself Albon Man, who became a joint inventor with him of several electric-lighting inventions, the promising results from which led to the formation, on July 8 of that year, of the Electro-Dynamic Light Company of New York. The objects for which this company was formed were stated as follows:

> "The production of light and power by means of electricity; the lighting of streets, buildings, and other places; producing, conducting, and distributing electrical currents for lighting and other purposes, and the manufacture and sale of all machinery necessary for or adapted to accomplish the purposes named."

Charles F. Brush early invented and perfected a dynamo, an arc lamp, and a method of operation whereby a number of such arc lamps could be used on one circuit, principally for street-lighting purposes. To make and sell Mr. Brush's inventions, there was organized the Brush Electric-Light Company, of Cleveland, Ohio.

In September, 1878, appeared the first announcement of Mr. Edison's discoveries in electric lighting, and on October 17, three months after the formation of the Electro-Dynamic Company to operate Sawyer and Man's electric-light inventions, the Edison Electric-Light Company, of New York, was organized. To introduce the inventions of Maxim and Weston, there was formed the

United States Electric-Lighting Company, of New York, and thus four large corporations were started almost simultaneously upon a career of competitive business. The energy and money since expended by each of these corporations in efforts to thwart the progress of the others has mutually embittered the interested parties to a degree that can with difficulty be comprehended by those not immediately concerned in the strife.

Mr. Edison, already a well-known inventor in telegraphy, apparently had his attention drawn to this subject by a visit to Mr. William Wallace, of Ansonia, Conn., in September, 1878. There he saw Mr. Wallace's dynamos feeding eight electric lights at one time, and also witnessed the transmission of power by electricity from the Naugatuck River, a quarter of a mile distant. The spirit in which he entered the electric-light business would seem to be indicated in the following extract from the New York *Tribune* of September 28, 1878:

"Mr. Wallace's machines produce electricity which can be made available for electric light." Mr. Edison continued: "I have let the other inventors get the start of me in this matter somewhat, because I have not given much attention to electric lights, but I believe I can catch up to them now." . . . "Now that I have a machine (Wallace's) to make the electricity, I can experiment as much as I please." "I think," he added, smiling, "there is where I can beat the other inventors, as I have so many facilities here for trying experiments." "If you can make the electric light supply the place of gas, you can easily make a great fortune," the reporter suggested. "I don't care so much for a fortune," Mr. Edison replied, "as I do for getting ahead of the other fellows."

Setting out with this determination, it is perhaps no wonder he has worked so energetically. Reviewing his inventions and utterances, it is evident that he believed from the beginning that the system of gas-distribution was the thing to be copied, and that electric conductors could be laid under the streets with branches or connections to each house, supplied by generators located in central stations; but this system necessitated the limitation of the electric pressure to that which the lamps could be made to endure—in practice about 110 volts. The formidable quantities of copper required to conduct the necessary volume of current at this low pressure soon led to the development of what is known as the Edison "three-wire" system of distribution, an improvement founded upon earlier patents of Sawyer and Brush. This system permits a pressure of 220 volts on a circuit equipped with 110-volt lamps, and requires for the whole installation only

one-quarter of the weight of copper conductors necessary with the two-wire system.

It must be constantly borne in mind that the pressure of this direct-current system is necessarily limited to 220 volts by the conditions of the lamp, and also that the underground mains in all directions are interconnected, forming what is termed a mesh-work, analogous to the gas-distribution system, but with very important differences, hereafter explained at length. The cost of copper required for mains of sufficient conductivity to avoid a decrease in light by reason of large consumption, even at moderate distances, was found to be prohibitive, and this fact necessitated a system of "feeders," through which the electricity is forced against a very considerable resistance. These feeders are connected at various points to the mesh-work of mains so as to maintain at such points an approximately constant pressure. The generators at the central stations deliver their product collectively into common feeders and mains, and with a large plant an enormous energy is constantly exerted in these mains.

Any plan of distribution involving the meshing of the mains underneath the streets, with all house wires connected directly thereto, is regarded by the majority of competent electrical engineers as in many respects radically defective ; so defective, in fact, that, unless the use of alternating currents can be prohibited, it seems destined to be wholly supplanted by the more scientific and in all respects (so far as concerns the users or occupants of buildings) far safer inductive system. Apparently sensible of this, Mr. Edison does not hesitate to say : "My personal desire would be to prohibit entirely the use of alternating currents."

The fact that the shocking accident which has given rise to the present discussion was, in all probability, the result of a direct continuous current, and that the burning of the unfortunate victim may have resulted from a low-tension current used for telegraphic or power purposes, apparently does not deter Mr. Edison from his self-imposed task of proving the low-pressure system to be the only safe one. It is, nevertheless, a common practice of the Edison Company to use uninsulated overhead wires for its 220-volt current for the purpose of economizing first cost, although it is well known that such a current is capable of burning a body subjected to it as effectually as in the case of lineman Feeks, provided the skin be sufficiently abraded to diminish the electrical resistance of the subject.

Accepting Mr. Edison's classification of the currents used for electric lighting, let us discuss them as follows :

" *First*—The low-tension continuous current, with a pressure not exceeding 200 volts, used for incandescent lighting.

" *Second*—The high-tension continuous current, with a pressure of 2,000 volts and over.

"*Third*—The high-tension semi-continuous, or pulsatory, current, with a pressure of 2,000 volts and over.

" *Fourth*—The alternating current, with a pressure of from 1,000 to 3,000 volts and over."

The first is not dangerous when a person comes into momentary contact with one wire, but no one can endure its passage through the body when the contact is made "in the most effective manner." I have witnessed the roasting of a large piece of fresh beef by a direct continuous current of less than one hundred volts within two minutes. Any one having access to electric lights operated by the low-tension underground system in New York can easily prove to his own satisfaction how much credence ought to be given to the assertion that a current of 200 volts can be passed through the human body without producing uncomfortable sensations. Let him connect a tin pan to one of the electric wires, and place therein a thick piece of beef, and upon this a gridiron of metal connected to the other wire. The electrical energy exhibited in the steaming and cooking of this beef may possibly surprise the experimenter. If the current is from an underground main, the experiment may be varied by connecting the gridiron to a water-pipe with like results. With even less than one hundred volts it is painful beyond endurance to press firmly with the hands the brushes or any bright brass-work of the dynamo, or to grasp any metal connected with the wires.

That a continuous current of moderate tension may produce death when the connection is continued for even a short time is shown by the published record of experiments conducted by Mr. A. E. Kennelly at the Edison Laboratory. With a continuous current of 400 volts a dog weighing fifty-seven and a half pounds was killed in forty seconds ; and in another instance, with 1,000 volts of continuous current, a dog weighing thirteen and a half pounds was killed instantly. That an alternating current of one hundred volts, even when effectively applied, does not kill is shown by two experiments on another dog. A continuous current of 304 volts was applied for thirty seconds, and then an alternating current of one hundred volts for sixty-five seconds ; yet the dog was unhurt.

But mark this important fact: the so-called "alternating current" used for these experiments on animals was not the alternating current of commerce, but was an Edison direct continuous current made alternating by a "pole-changer," producing an effect incomparably more dangerous than the true alternating current under discussion, because of the exaggerated tension resulting from the partial discharge of the field-magnets of the dynamo, which act in this case like a Ruhmkorf coil of enormous dimensions.

The power of destruction residing in the low-tension current under certain conditions is best illustrated by quoting from Mr. Edison's own article, where he says:

> "Near the corner of William and Wall Streets, New York, the underground conductors of the Edison Illuminating Company became crossed, and the current which was passing through them at a pressure of only one hundred and ten volts melted not only the wires, but several feet of iron tubing in which they were incased, and reduced the paving-stones within a radius of three or four feet to a molten mass."

He adds: "This system is so arranged that consumers are not affected by such accidents as these." But it is, nevertheless, true that every consumer is directly connected to the mains, so that it is evident that the reverse of this statement would have more truly represented the actual possibilities of the case.

Concerning the three other conditions of current referred to by Mr. Edison, he classes them, and rightly so, as dangerous to life, although momentary contacts have repeatedly been made with wires carrying 1,000 and even 2,000 volts of each of these currents, without fatal results. In fact, there have been hundreds of cases in which momentary contact with an alternating current of 1,000 volts and over, as well as with pulsatory and continuous currents, has resulted only in painful shocks, unaccompanied by permanent injury.

The reader of Mr. Edison's article who is unfamiliar with the alternating system of distribution would naturally infer that in practice the same voltage is carried on the house wires as on the mains, as in the Edison system; but such is never the case under any circumstances. In this complete disconnection of the street and house wires is found the reason of the positive safety both to life and property enjoyed by the users of the alternating system. It is one of the great advantages of this system that it admits of the use of high voltages for the street mains, and of wholly separate and independent currents, with absolutely

safe voltage, for all wires within buildings—a condition which is infallibly secured and maintained by converters, or transformers, located in or near each building. Each transformer of electric energy is composed of two separately-wound and insulated coils, one of thin wire connected to the street mains, and the other of thick wire connected to the wires of the building. One of the most beautiful features of the alternating system is that when currents of electricity are sent back and forth with almost inconceivable rapidity through the coil of thin wire, there is induced in a neighboring coil of thicker wire an equivalent amount of electrical energy, but at the same time so modified that the voltage, which may be 2,000 in the thin coil, need be only fifty in the thick coil, the volume of electricity being as many times increased as the pressure or voltage is diminished. A current of fifty volts is used in practice, as it is now well established that lamps of this capacity are far more durable and give a better light, with much greater economy, than the 100- or 110-volt lamps. The two coils being absolutely separated from each other by effective insulation through which the current in the primary wire cannot possibly penetrate, it follows that the alternating system has an enormous advantage over the direct system in respect of absolute safety to the consumer.

It seems possible that the time is not far distant when the regulations governing the distribution of electricity will rigidly prohibit direct electrical connection between the street wires and the local service-wires inside houses, thereby excluding from dwelling-places all the dangerous effects possible to ensue from accidental leakages in the underground system.

The forebodings of Mr. Edison concerning the results of the leakage of current from the underground mains have perhaps been in great part suggested by difficulties experienced in the working of his own system. The Edison underground lines are made up of a great number of short sections of iron pipe, each containing a copper rod, with a plastic insulating material forced between the copper and the iron. These sections are about sixteen feet long and are laid in trenches, and united at the joints like gas-pipes. These pipes are usually laid above the frost-line, and are necessarily affected by changes of temperature, which cause the iron pipes to move at the joints. It is, therefore, not unusual to find that after a short time the electrical leakage becomes sufficient to light a number of lamps when connection

is made between a water-pipe and one of the mains—a fact well known to insurance inspectors. The Edison Company continues to use this system, although cables are now made capable of withstanding 2,500 volts of either alternating or direct current with even greater security than Mr. Edison has been able to provide for the 220 volts employed in his low-tension system.

One of the most perfect cables of to-day is a copper wire covered with a thick insulation, over which lead is pressed with very great force, thereby expelling air and gases, and solidifying the insulating material between the lead and copper. There is then woven upon the lead a textile envelope saturated with a water- and gas-proof compound. The continuous sections of this cable reach from one man-hole to another, a distance of several hundred feet, and can easily be drawn in and out of the ducts provided for them. Where one piece of cable is joined to another, an electric connection is made and well insulated, then encased in lead, which is afterward soldered to the ends of the respective cables. A cable of this character is uninfluenced by changes of temperature and is subject to little deterioration. To guard against its being pierced by a spark of static electricity, a very simple device is attached to it, offering an easier path for the electricity than through the insulation.

One of the differences alluded to, as existing between the low-tension, continuous-current underground system and a gas-pipe system, is that with reference to leakage. A gas leak is local and incapable of producing effects at a distance. With electricity, however, the aggregate effects of all the leakages from an underground system may be suddenly concentrated at any point within that system, as by one of the house wires coming in contact with a metal pipe, and such a contact may result even from the work of a mouse; whereupon the leakage of the entire net-work, which may amount to a large percentage of the total current, will be concentrated, and the surrounding material affected (although perhaps to a less degree) in the manner described by Mr. Edison in the reference to the currents at the corner of William and Wall Streets.

The interconnection of the conductors for the purpose of reducing the original investment has, in another important respect, a contrary effect from the meshing of gas-mains. In the case of the latter, the fracture of a pipe at one place, while it may cause a considerable leak, does not necessarily extinguish the lights of

all the consumers. The grounding of one of the wires of an underground circuit, however, affects the entire mesh-work; and a cross between the wires may extinguish the lights of an entire district for a considerable time.

As to the accidents from electric currents, the records of deaths in the city of New York show that there were killed by street-cars during the year 1888, 64 persons; by omnibuses and wagons, 55; and by illuminating gas, 23; making the number killed by the electric current (5) insignificant compared with the deaths of individuals from any of the other causes named. The placing of the wires underground would eliminate many of the causes of accidents from electric currents, and they may all be prevented by the employment of reasonable and well-understood safeguards. Mr. Edison's statement that the putting of the wires underground will, instead of diminishing, increase the danger to life, is little less than amazing, at least when considered in connection with his advocacy of his own underground system. The repeated and violent explosions of gas in the man-holes of the Edison system, and in connection with the underground systems of the telephone and telegraph companies, have certainly shown that electricity from any source, either from low-tension electric-light, telephone, or telegraph currents, either of which is capable of producing a spark, may be the cause of a serious catastrophe, although there is no doubt that the accumulation of explosive mixtures within these chambers can be effectually prevented. Inasmuch as Mr. Edison's argnments against underground wires generally are equally applicable to his own system, it would seem, logically, that, if his views are to prevail, all electric wires must cease to serve the public. The experience of the cities of Chicago and Philadelphia in the use of underground cables for high-tension currents, to say nothing of the large number of cables laid underground in Rome, Berlin, Milan, and in other cities, indicates that the success of properly-constructed underground systems, whether for currents of high or low tension, has been established beyond question.

There is one radical difference between the alternating and the continuous low-tension system which should be fully understood. It has been shown that in the alternating system the street mains are absolutely disconnected and detached from the house mains, while the low-tension system necessitates the

meshing of all underground mains into one net-work and the supply of the current to that system by a series of feeders. In fact, it necessitates at times the supply of an enormous electrical energy to supply the demand. With the alternating system the practice is not to mesh the wires, but to run independent pairs of wires connecting the switch-board in the station with the thin wires of the converters. These wires are designed to supply only about 1,500 to 2,000 lights per pair, and are made of such a size that there is no appreciable decrease in the lights at the farther end, even if there is a very large consumption of current. Each of these pairs of mains can, therefore, be provided at the station with safety devices which will instantly and automatically cut off the current in the event of a cross-connection taking an abnormal current from the dynamo. Such safety devices cannot be made available with the low-tension system.

Mr. Edison is, moreover, unfortunate in his reference to the use of electric currents abroad. Under the British Electric-Lighting Act of 1888 the Board of Trade has issued a set of regulations. Concerning high-pressure conductors it says :

> "9. *High-Pressure Conductors to be Insulated.* Every high-pressure aërial conductor must be continuously insulated with a durable and efficient material, to be approved by the Board of Trade, to a thickness of not less than one-tenth part of an inch, and in cases where the extreme difference of potential in the circuit exceeds 2,000 volts, the thickness of insulation must not be less in inches or parts of an inch than the number obtained by dividing the number expressing the volts by 20,000."

It will be seen that these regulations provide not merely for 2,000 volts, which is double that used in the American alternating system, but for any voltage whatsoever which the electric companies may desire to carry.

In a recent authorized publication it is stated that the main characteristics of the Edison system are as follows :

> *First*—Subdivision of generating units to secure reliability and economy of production.
>
> *Second* –Meshing of distributing conductors in a common net-work throughout the entire area to be supplied, to secure uniform distribution.
>
> *Third*—A system of special feeding conductors to apportion equally the supply of energy to the demand throughout the area covered by the system of conductors.
>
> *Fourth*—A system of indicators to denote in the station variations of pressure at any point in the area of consumption.
>
> *Fifth*—A system of regulation to compensate for any variation of pressure.

The main characteristics of the alternating system contrast

with these in a marked manner. These characteristics may be stated as follows:

First—Large generators located in central stations at points convenient for coal and water supply, and away from residences.

Second—A series of mains running from the station, each set of mains having a capacity of not exceeding 1,500 lights, and each pair of mains extending to the station, so that the lines are only interconnected at the switch-board in the station.

Third—By reason of the limitation of the number of lights on each circuit, the leakage on any one circuit is reduced to a minimum.

Fourth—The interruption or burning-out of any one circuit can have no effect upon other circuits, the contrary being a most serious defect in a system wherein the wires are meshed.

Fifth—Absence of numerous and costly regulating contrivances.

Sixth—Ability to use within all houses a fifty-volt current, whereby the most efficient lamps can be utilized.

Seventh—Absolute separation of the street mains from the house mains, thereby preventing injury or danger from the leakage from the street mains.

Eighth—The use of a mechanical meter, which accurately records the entire electrical energy consumed in the house.

Ninth—The easy regulation of the current if required, so that the lights may be turned up and down without expensive and wasteful machinery.

There is not on record a solitary instance of a person having been injured or shocked from the consumers' current of an alternating system. This is wholly due to the fact that the converted current within the buildings supplied need not exceed fifty volts, and that the street mains and the house wires are absolutely detached from each other, so that there is no possibility of a shock being received from leakage or short-circuiting in the high-tension street mains.

The fire-risk from electricity is the one most to be feared. With the continuous current, whenever there is occasion to put out a number of lights by the movement of a switch, it not infrequently happens that a dazzling arc of blue flame is formed which has to be blown out. With the alternating system it is impossible to form any considerable arc, even if the switch controls a thousand lights, the rapid reversals of the current having the effect of preventing its establishment.

Mr. Edison's observations concerning the efforts of his competitors in the direction of saving in investment are no less applicable to the desires of the suppliers of his own system. At the annual convention of the Edison Illuminating Companies at Niagara, in August of this year, the following resolutions were offered by Mr. Gilbert, of the Detroit Edison Station:

"*Resolved*, That the Association respectfully call to the attention of the Edison General Electric Company the difficulties under which local companies are now laboring in consequence of the lack of

"1. An efficient and inexpensive arc-light system.

"2. An arc lamp which can be economically operated on the three-wire system.

"3. A flexible method of enlarging the territory which can be profitably covered

from their stations for domestic lighting *by higher pressures* and consequently *less outlay of copper* than that involved by the three-wire method.

"We earnestly appeal to the parent organization to supply these deficiencies."

The proceedings of the convention also contain the following:

"The address of Sir William Thomson, as president of the physical section of the British Association in 1882, contained this memorable passage: 'Nothing above 200 volts, on any account, ever should be admitted into a ship or house or other place where safeguards cannot be made absolutely and forever trustworthy against all possible accident.' This opinion accords with what Mr. Edison has always maintained—that in the long run every system will fail which does not (for domestic service) use a low-pressure current."

This is precisely what the alternating system supplies. The successful use of arc-lamps depends upon high voltages. Neither Mr. Edison nor any other person has yet been able to supply the requirements of the public by means of a low-tension arc-lighting system.

A careful consideration of the whole subject proves that it is possible to light all the buildings within a city by means of electricity distributed by an underground system, wherein there shall be no connection whatever between the underground system and the wires within the buildings. It has been demonstrated that an incandescent lamp operated by a fifty-volt current will give more light at a given cost than a 110-volt lamp; and, these two things being admitted, it follows that, if there are to be any restrictive regulations with reference to electric lighting, they might more properly be: *First*—That the electro-motive force within any building shall never exceed one hundred volts; *Second*—That no underground system shall be placed in electrical connection with the wires in the buildings; *Third*—That no underground system shall be permitted which does not provide for the renewal and repair of the mains without digging up the streets.

In conclusion it is worthy of note that for three years past the purchasers of apparatus for electric lighting, who are at perfect liberty to buy from any company, have, for the most part, preferred to use the alternating system, so that to-day the extension of that system for central-station incandescent lighting is at least five times as great as that of the direct current. If the opinion of these persons, who can have no interest except to purchase that which they believe to be the best, is of any value, then the alternating system has been demonstrated to be the one which can give to the public that which they so much desire—a safe, cheap, efficient, and universally-applicable system of incandescent electric lighting.

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